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. . . Plus VisiCalc Pointers

ABOUT THIS ISSUE

We've all heard a lot lately about retiring as a millionaire by establishing an IRA, or Individual Retirement Account. If you haven't already begun one for yourself, *A Look At "Everybody's Tax Shelter"* will be of more than passing interest to you. If you have opened an IRA, you may find it worthwhile to use the VisiCalc® program for reevaluation or future planning. If you work with pensions, and particularly with defined benefit plans, you may find the second part of the article quite useful. In any event, if you have yet to work out the VisiCalc expressions necessary to find the deposit to a sinking fund, or for an annuity due, you'll find them in the IRA article.

April 15th is approaching, so we offer a guide to using the VisiCalc program to complete Schedule A, Itemized Deductions. Even if you do not do your own taxes or itemize deductions, a technique for keeping track of expenditures by category is shown in *The Ides of April Are Upon Us.* The article uses @IF and @CHOOSE, but if you do not have those functions in your version of the VisiCalc program, substitute expressions are provided in the captions to Figures 5 and 7.

In a more specialized vein, *Calculating Internal Rates of Return* should provide you with a useful and economical method to perform what are often extremely tedious calculations. Since IRR calculations require iteration, and it is the nature of iterative algorithms to go awry under certain conditions, the solution we have developed has some limitations. It works well on most problems, but it can be fooled. You'll find a substitute expression for @IF in the caption to Figure 9.

A LOOK AT "EVERYBODY'S TAX SHELTER"

The Economic Recovery Tax Act of 1981 opened the way for taxpayers to set up tax favored retirement plans called Individual Retirement Accounts, or IRAs. Such plans permit persons to deposit $2000 or 100% of gross income, whichever is less, into an account the earnings of which will not be taxed until money is drawn from it. Deposits made into IRA accounts may be deducted from an employee's gross income, and therefore lower his or her taxable income.

It is not our intention to explore the tax or investment implications of IRAs. Rather, we shall show you how to use the VisiCalc® program to analyze some of the key decisions that you must make if you want to establish an IRA, or if you are advising prospective IRA owners.

There are two basic ways to look at an IRA, or any similar plan. The first answers the question: If I deposit X dollars a year for Y years at Z interest rate, how much will I accumulate? The second answers the question: If I want an income at retirement of X dollars, how much must I deposit annually to create it? Those questions describe the two classes into which all retirement plans (whether individual or corporate) fall: defined contribution and defined benefit plans. Because the law sets limits to the contribution that an individual may make, an IRA is a defined contribution plan. And although there is no such thing in the law as a defined benefit IRA, some kinds of analyses appropriate to such plans can be fruitfully applied to IRAs.

As always, financial forecasting in an uncertain world calls for making assumptions that may not be valid a month later. There are several assumptions that must be made about IRAs, the most important of which concern the effects of inflation and the rates of return that can be expected. Back in the old days, say early 1979 (before the VisiCalc program was released), evaluating the different effects of differing assumptions was a time consuming and difficult process . . . but those were the old days.

We'll look first at the simpler of the two approaches, the defined contribution IRA.

How Much Will I Accumulate?

In a sense, how much you will accumulate in an IRA is almost irrelevant. What matters more is how many goods and services the money will buy and how long it will last. So although we do calculate how much money can be amassed, that is only an intermediate step in the analysis.

To reproduce the sheet shown in Figure 1, begin by setting up your sheet with the commands:

```
/GOR
/GFI
```

to calculate across the rows and show integers in all locations except those locally formatted.

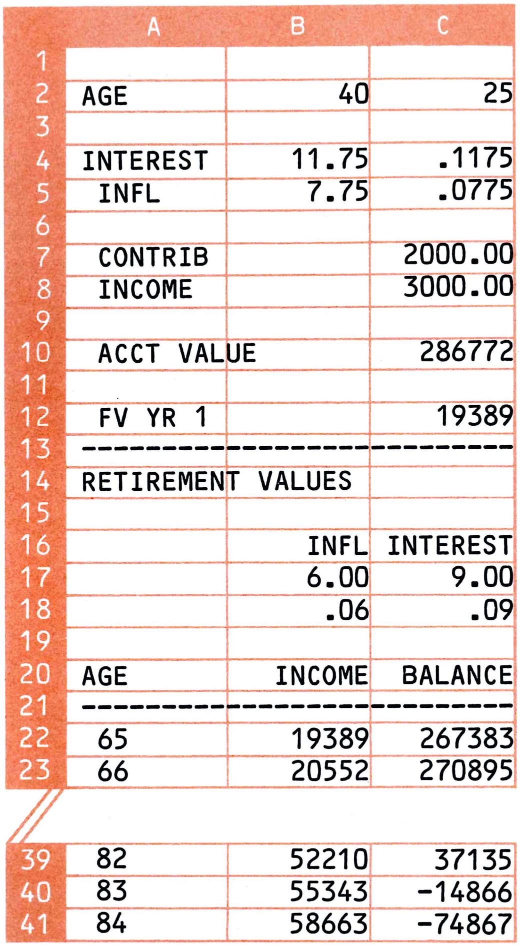
We've assumed that age 65 is the retirement age, and that from the present until then, regular annual deposits will be made into the IRA. After entering 40 in B2, enter:

```
>C2:65-B2
```

At B4 and B5 are assumptions about the rates of interest and inflation. Whether you agree with our estimates of 11.75% and 7.75%, enter those figures temporarily so that you can check the correctness of your entries as we proceed. Each is expressed as a percent, and converted into a decimal with the expressions:

```
>C4:/FG+B4/100
>C4:/R:C5:R
```

We have formatted C7 and C8 with /F$ and entered $2000, the most the law allows, as the level annual deposit, and $3000, a sum that will become the basis of future income. Later, we will compound the income amount, so that in theory it will buy the same goods and services in the future as it does today.



	A	B	C
1			
2	AGE	40	25
3			
4	INTEREST	11.75	.1175
5	INFL	7.75	.0775
6			
7	CONTRIB		2000.00
8	INCOME		3000.00
9			
10	ACCT VALUE		286772
11			
12	FV YR 1		19389
13	----------	----------	----------
14	RETIREMENT VALUES		
15			
16		INFL	INTEREST
17		6.00	9.00
18		.06	.09
19			
20	AGE	INCOME	BALANCE
21	----------	----------	----------
22	65	19389	267383
23	66	20552	270895
39	82	52210	37135
40	83	55343	-14866
41	84	58663	-74867

FIGURE 1. *This sheet shows how much a 40 year old will accumulate in 25 years at 11.75% interest, and how long it will last, given the assumptions about inflation, earnings, and income shown. The values in column C may be written with @MAX to display 0 if the balance is negative. If so, the first expression in the column would be:*

>C23:@MAX(C22*(1+C18)-B23,0).

To learn how much the maximum allowable deposit will amount to at retirement we use the general formula for an *annuity due*, that is, a series in which payments are made at the beginning of each period. Savings accounts, insurance premiums, and rents are examples of annuity due calculations. The general formula is:

$$Deposit * \frac{(1 + Interest\ Rate)^{Time} - 1}{Interest\ Rate} * (1 + Interest\ Rate)$$

Deleting the final term, (1 + Interest Rate), from the general formula gives the formula for an *ordinary annuity*, a series in which payments are due at the end of each period, as is the case with loans and mortgages.

On our sheet the VisiCalc formula is entered at C10 as:

```
>C10:+C7*(1+C4^C2-1/C4)*(1+C4)
```

Given the assumption that 11.75% is a reasonable rate of interest for 25 years, we show that an annual deposit of $2000 grows to $286772. That looks like a lot of money, but the real questions are: How much will it buy? And for how long?

Since IRAs are supposed to supplement other savings and pension plans, it is reasonable to assume that they should provide no more than a small proportion of an individual's retirement income. So we chose $3000 as the income level the IRA should produce. But as long

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as inflation continues, $3000 today will buy more than will $3000 a year from now. Twenty-five years from now, at the same rate of inflation, $3000 will buy very little indeed. To equate the purchasing power of $3000 today with its purchasing power 25 years hence, we must compound that sum, too.

The general formula for compounding a single sum is:

$$(1 + \textit{Interest Rate})^{\textit{Time}} * \textit{Sum}$$

On our sheet the necessary formula is entered at C12 as:

```
>C12:1+C5^C2*C8
```

That shows that if inflation continues for 25 years at 7.75% per year, it will take $19389 to buy what $3000 buys today.

With both the future value of $3000 and the accumulated deposits available, we can construct a table that shows how long the money will last.

There's no reason to expect that inflation will magically halt at the time of retirement, so we have built in a factor for post-retirement inflation. We have assumed, though, that after retirement the rate of inflation will not be as high as before retirement, since some factors that influence it today are not likely to apply. For example, for most persons, housing costs and mortgage rates, which currently contribute to the rate of inflation, will not be a factor (though medical costs as a proportion of their budgets might rise). Offsetting the potentially lower rate of inflation is a reduction in the rate of interest earned. We assume an interest rate that is more conservative, reflecting the greater necessity of preserving capital after retirement than before.

The column AGE begins with 65, and shows the age at the beginning of each year after retirement. Enter:

```
>A22:/FL65
>A23:/FL+A22+1®/R:A24 . . . A41:R
```

The table itself begins with inflation (entered as 6%) and interest (entered as 9%) in cells B17 and C17, and expressed as decimals in B18 and C18. Enter:

```
>B18:/FG+B17/100
>B18:/R:C18:R
```

At B22 the future value of the first year's income requirement is entered with:

```
>B22:+C12
```

That is compounded for each year thereafter with the entries:

```
>B23:+B22*(1+B18)
>B23:/R:B24 . . . B41:RN
```

The column created by those entries shows that if inflation continues at 6% for 20 years after retirement, then it will take $58663 to buy what $19389 buys at the beginning of the period.

In column C of the table, under BALANCE, the first year's retirement income is deducted from the accumulated value of the IRA with the entry:

```
>C22:+C10-B22
```

That BALANCE will earn interest, though, and so for the next and subsequent years it is compounded and recalculated with the entries:

```
>C23:+C22*(1+C18)-B23
>C23:/R:C24 . . . C41:RNR
```

Now, by scrolling down the table, you can see that the balance remaining after income is taken at age 82 is $37135, or approximately $14800 less than the amount needed to go through age 83. In short, given the various assumptions made about interest and inflation and income, if you are 40 now and begin depositing $2000 annually in an IRA, you can expect it to last a little more than 18 years beyond retirement at age 65.

As it stands, the sheet you have created tells you far more about the IRA decision than most of what is available in the advertising brochures that you are likely to see. Moreover, unlike those sources of information, the sheet can be tailored to fit your situation, and allows you to test a variety of possibilities.

The second way of looking at an IRA involves many of the same considerations as the approach above. However, although both use some income amount, if you vary the income level in the above application, it has no effect on the amount of the deposit. In the approach that follows, varying the income level

KEY TO CONVENTIONS USED IN SATN

The VisiCalc® program is available on personal computers manufactured by Apple, Atari, Commodore, Hewlett-Packard, IBM, and Radio Shack. To reduce any confusion arising from the differences among the keyboards of those computer systems, SATN uses a standard symbol and name to represent certain commonly used keys.

The symbol ® and the word RETURN are used as synonyms for the keys known as ENTER, ENDLINE, and RETURN. The symbol ^ is used to represent an exponentiation operator.

To make VisiCalc documentation more readable, the program was designed so that the colon (:) has the same effect as RETURN in some commands, as when ending the > command or separating various elements of the replicate command.

In examples of what to type, type exactly what you see and press RETURN at the end of every line. Users of the HP-83/85 may find it necessary to add parentheses to some of the expressions included in the text. For example, 3+4*5 should be (3+4)*5 on an HP-83/85.

Throughout SATN, one typeface represents both VisiCalc input and output (what you should type and what you will see on the screen). The typeface looks like this:

```
This line is typeset in OCR-B.
So is this: +A1+B1*3.25
```

To allow you to type the formulas directly on a VisiCalc sheet, examples in SATN specify coordinates, like A1, rather than the names of the values they represent. When actually typing a formula, you can use the arrows to point rather than using the > command.

and the amount of time over which the income will be paid, determine the amount of the deposit that must be made.

Calculating a "Defined Benefit" IRA

Set up a clear sheet with the commands:

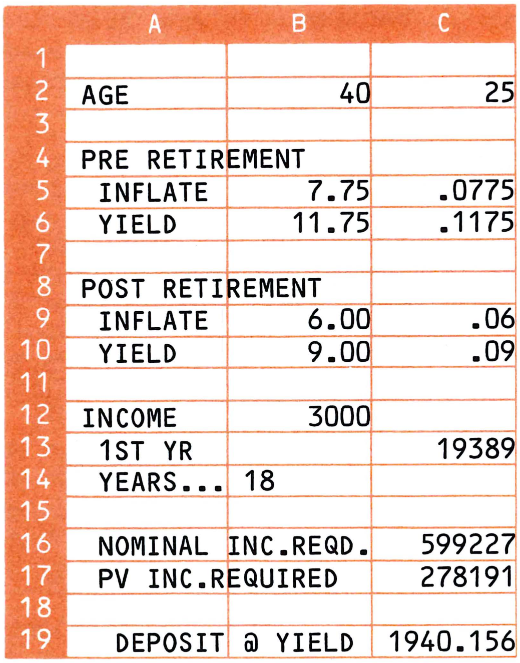
```
/GOR
/GFI
```

We will use the same age, interest, and inflation rates as above, so enter the labels and interest rates shown in Figure 2. You will have to format several cells with local commands to display the same values as shown in the figure. As above, to determine the time available enter:

```
>C2:65-B2
```

To express the percentages shown in B5, B6, B9, and B10 as decimals enter:

```
>C5:/FG+B5/100®/R:C6:R
>C5:/R...C6:C9:RR
```



	A	B	C
1			
2	AGE	40	25
3			
4	PRE RETIREMENT		
5	INFLATE	7.75	.0775
6	YIELD	11.75	.1175
7			
8	POST RETIREMENT		
9	INFLATE	6.00	.06
10	YIELD	9.00	.09
11			
12	INCOME	3000	
13	1ST YR		19389
14	YEARS...	18	
15			
16	NOMINAL INC.REQD.		599227
17	PV INC.REQUIRED		278191
18			
19	DEPOSIT @ YIELD		1940.156

FIGURE 2. *If you do not have the @CHOOSE function you can use @LOOKUP. To do so, insert a row at A15, then replicate F13 . . . Y13 into F15, making value references relative. The entries at C17 and C18 should be:*

>C17:@LOOKUP(B14,F15 . . . Y15)
>C18:@LOOKUP(C17,F16 . . . Y16)

The calculation for the income in the first year of retirement is identical to the one shown above. Enter:

```
>C13:+B12*(1+C5^C2)
```

The next series of calculations takes place beginning on row 13 and to the right of the main body of the part of the sheet shown in Figure 2. The reason for this location is so that all values calculated above and to the left will be included in the series. Figure 3 shows the appropriate labels and the calculations done on the variables that have been entered. The row labelled YEAR is primarily identification, though if your version of the VisiCalc program does not contain the @CHOOSE function you will have to use the row as the index for @LOOKUP (see the caption to Figure 3 if you do not have @CHOOSE). In the row labelled COMPOUND is the amount, year by year, required to maintain the purchasing power of the income expected at retirement. We have begun the series with 0 at F14, for reasons that will be apparent later. At G14 is the entry:

```
>G14:+C13*(1+C9)
```

The next entry compounds the value calculated at G14. Enter:

```
>H14:+G14*(1+C9)
```

That is replicated across the sheet with:

```
>H14:/R:I14...Y14:RN
```

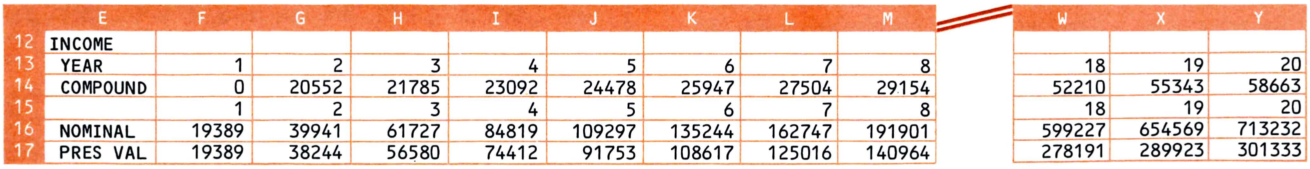
Now, by scrolling across the sheet to Y14, we can see that 20 years after retirement it takes $58663 to purchase what $19389 would purchase at retirement (the same values calculated in the first part of this article).

The next row, NOMINAL, refers to the cumulative absolute number of dollars involved in the stream of retirement income shown in the row above. Enter:

```
>F15:+C13+@SUM(F14...F14)
>F15:/R:G15...Y15:NNR
```

Note that by making the end of the @SUM range relative, each succeeding entry in the row includes one additional year's income.

The entries made thus far show that in the second year of retirement, $20552 will be required to purchase the same amount of goods and services that $19389 would have purchased the year before. But that money will not be needed for a year, so a smaller sum can be allowed to compound for one year in order to produce $20552. Since compounding is the reverse of discounting for present value, we can use the @NPV (Net Present Value) function of the VisiCalc program to perform the necessary calculations.



	E	F	G	H	I	J	K	L	M	W	X	Y
12	INCOME											
13	YEAR	1	2	3	4	5	6	7	8	18	19	20
14	COMPOUND	0	20552	21785	23092	24478	25947	27504	29154	52210	55343	58663
15		1	2	3	4	5	6	7	8	18	19	20
16	NOMINAL	19389	39941	61727	84819	109297	135244	162747	191901	599227	654569	713232
17	PRES VAL	19389	38244	56580	74412	91753	108617	125016	140964	278191	289923	301333

FIGURE 3. *As shown above, this figure is for use with the @LOOKUP expressions described in the caption to Figure 2. When using @CHOOSE, as described in the text of the article, rows 16 and 17 in this figure would actually be rows 15 and 16 on the sheet.*

The @NPV function assumes that the first value in the range specified is a sum of money that will be due at the end of the first period. Since we anticipate that the income calculated at C13 will be taken when retirement begins, we cannot include it in the range. However, we must add it to the calculation of the present value of the retirement income stream.

Thus the first entry in the row labelled PRES VAL is:

```
>F16:+C13
```

The next entry treats the second year's income as the first in the stream, discounting it by the rate of interest that is expected after retirement, and to which is added the income taken in the first year. Enter:

```
>G16:+F16+@NPV(C10,G14...G14)
```

The value returned by that entry is the amount needed to compound to the second year's income, plus the income taken in the first year. To calculate subsequent years the entry in G16 is replicated to the 20th year with the entry:

```
>G16:/R:H16...Y16:NNNR
```

As above, by making the end of the range relative, we have calculated the cumulative present value of the stream of retirement income. Note that these calculations do not give the present value of the income stream measured from today, but the present value measured from the time of retirement.

Now enter at B14 the number of years over which the income will be paid. Because our earlier analysis showed that a $2000 deposit would produce income for just over 18 years, we have entered 18 at B14. Enter:

```
>B14:18
```

At C16 we can now show the nominal income required to produce the equivalent of $3000 income beginning 25 years hence and lasting for 18 years. Enter:

```
>C16:@CHOOSE(B14,F15...Y15)
```

That returns 599227 as the absolute number of dollars. To find the present value of the income stream, enter:

```
>C17:@CHOOSE(B14,F16...Y16)
```

That should return 278191, which is the amount of money that should be on hand at retirement to provide the necessary income. What we must do now is calculate how large an annual deposit is required to create that sum.

The general formula to calculate a sinking fund, which is the problem at hand, is:

$$\frac{\textit{Interest Rate}}{(1 + \textit{Interest Rate})^{\textit{Term-1}}} * \textit{Sum Required}$$

That formula, however, assumes that the first deposit to the sinking fund will be made at the end of the first period. In other words, it is an ordinary annuity calculation. In the case of an IRA or some similar plan, we must use an annuity due calculation. To convert the above general formula we must divide the result by (1 + Interest Rate). Thus, the entry on our sheet is:

```
>C19:/F$(C6/(1+C6^C2-1)*C17)/(1+C6)
```

That entry returns 1940.16, which, if it were entered as the annual deposit on the sheet shown in Figure 1, would show that after taking the income at age 82, there would be a balance remaining of $3. (If you format cell C19 with /FG and expand the column width to 12, the value displayed will be 1940.155733. If that is entered on the other sheet, the remainder will fall to less than $1.)

At this point you can adapt either of the approaches shown in this article to your own circumstances simply by varying the assumptions made concerning inflation, earnings, your age, the amount of income you would like to enjoy, or the period during which you would like to enjoy it. And you should now be in a position to make an IRA decision that is more useful to you, if only because it is a more thoroughly explored decision.

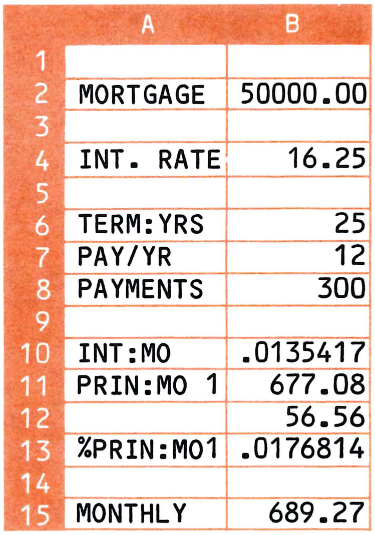
FOR TRS80 MODEL I USERS

The calculation of the payment on a mortgage shown in SATN, Vol. I, No. 2, as several readers pointed out, works only within certain limits before returning ERROR. The problem stems from the large, negative exponent that the calculation requires. At the time we went to press we were unaware of the problem, unique to TRS-80 Model I VisiCalc® users, and we apologize for any inconvenience that it may have caused our readers.

We had started to develop an expression to solve the problem when Tony Rairden and Charley Taylor, of Atlantic Aviation Corporation, provided us with a solution. Their solution consists of breaking down the expression we used into several parts, each of which is calculated separately, and then reassembling them.

Figure 4 shows a sheet on which the calculation is done for the Model I. The key expressions are:

```
>B8:/FI+B6*B7
>B10:/FG+B4/100/B7
>B11:+B2*B10
>B12:1+B10^B8
>B13:/FG1/B12
>B15:/F$+B11/(1-B13)
```

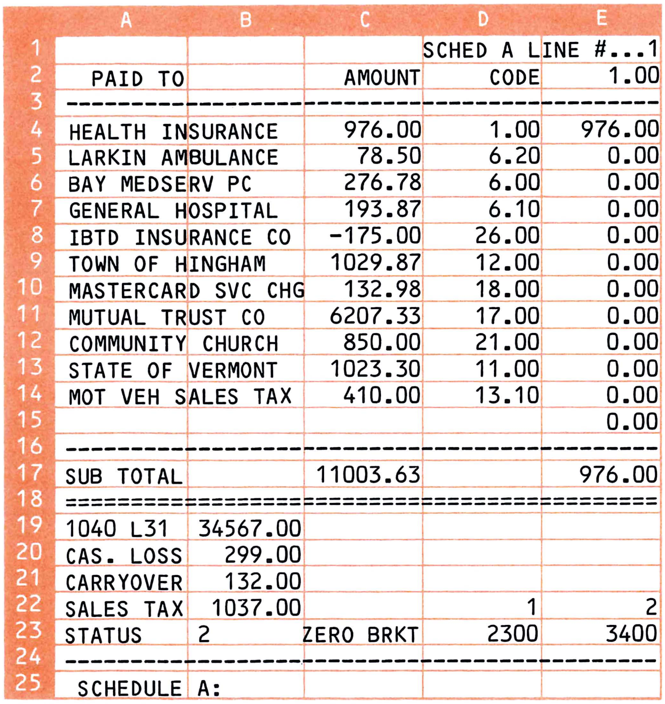


	A	B
1		
2	MORTGAGE	50000.00
3		
4	INT. RATE	16.25
5		
6	TERM:YRS	25
7	PAY/YR	12
8	PAYMENTS	300
9		
10	INT:MO	.0135417
11	PRIN:MO 1	677.08
12		56.56
13	%PRIN:MO1	.0176814
14		
15	MONTHLY	689.27

FIGURE 4. *The sheet for calculating the payment on a mortgage on the TRS80, Model I.*

THE IDES OF APRIL ARE UPON US

Almost everyone who itemizes deductions recalls wading at least once through stacks of receipts, cancelled checks, notes, and the miscellaneous bits of paper that constitute the playing pieces in the Filing Time game. Fortified by black coffee and armed with pencil, paper, calculator, and eraser they've plunged in, sorting and resorting, adding and re-adding until completing Form 1040A, and most importantly, Schedule A.



	A	B	C	D	E
1				SCHED A LINE #...	1
2	PAID TO		AMOUNT	CODE	1.00
3	--------	--------	--------	--------	--------
4	HEALTH INSURANCE		976.00	1.00	976.00
5	LARKIN AMBULANCE		78.50	6.20	0.00
6	BAY MEDSERV PC		276.78	6.00	0.00
7	GENERAL HOSPITAL		193.87	6.10	0.00
8	IBTD INSURANCE CO		-175.00	26.00	0.00
9	TOWN OF HINGHAM		1029.87	12.00	0.00
10	MASTERCARD SVC CHG		132.98	18.00	0.00
11	MUTUAL TRUST CO		6207.33	17.00	0.00
12	COMMUNITY CHURCH		850.00	21.00	0.00
13	STATE OF VERMONT		1023.30	11.00	0.00
14	MOT VEH SALES TAX		410.00	13.10	0.00
15					0.00
16	--------	--------	--------	--------	--------
17	SUB TOTAL		11003.63		976.00
18	========	========	========	========	========
19	1040 L31	34567.00			
20	CAS. LOSS	299.00			
21	CARRYOVER	132.00			
22	SALES TAX	1037.00		1	2
23	STATUS	2	ZERO BRKT	2300	3400
24	--------	--------	--------	--------	--------
25	SCHEDULE A:				

FIGURE 5. *If you use the VisiCalc program as a checkbook, the entries under PAID TO can be transferred by using a DIF file. If you do not have @CHOOSE, add the series 1 . . . 5 in D22 . . . H22.*

We cannot tell you what you can or cannot deduct, or what the permissible acceptable limits to certain deductions may be. But as a VisiCalc® program user, if you haven't done so already, it is still not too late to put the program to work to help yourself breeze through Schedule A. And, if not breeze through, at least make it a great deal easier.

Sorting Your Deductions

The first step in filling out Schedule A is to sort each deductible item into the appropriate category. We have set up the sheet shown in Figure 5 to do that automatically as each deductible item is entered.

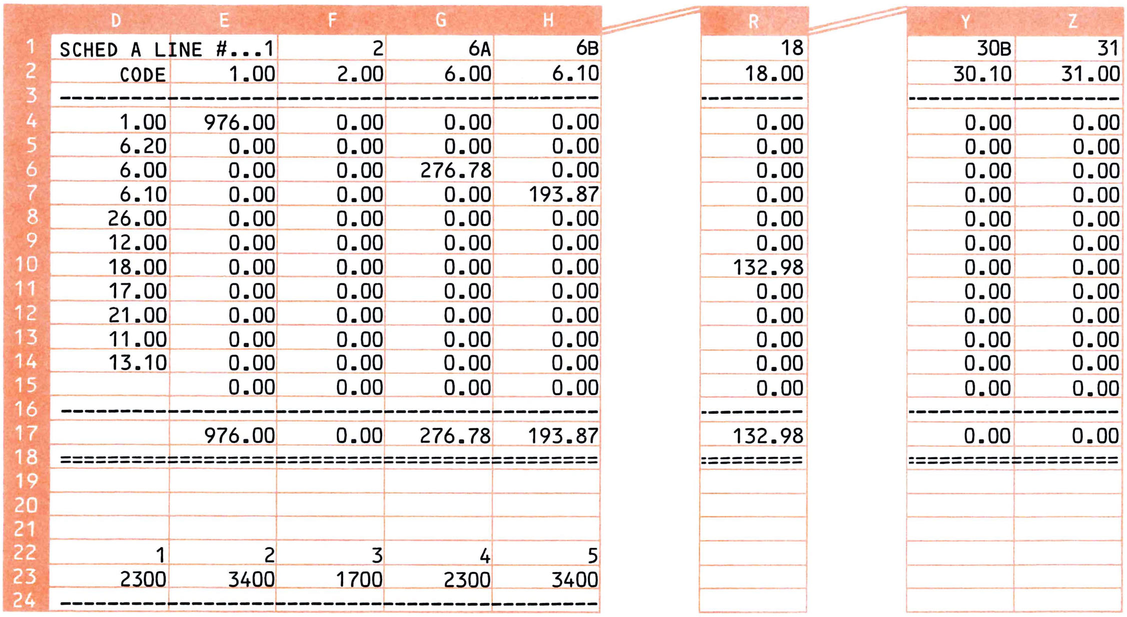
Since Schedule A uses numbered lines, we can code each item entered under PAID TO according to the line on which it should appear. The only difference between the codes we use and those on Schedule A is that we have used completely numeric codes for any line that is coded alphanumerically on the Schedule. For example, Line 6a of Schedule A (for Doctors, dentists, nurses, etc.) becomes 6 on our sheet; 6b (Hospitals) is 6.1; and 6c (Transportation) is 6.2. Given those codes, the expenses entered in column C under AMOUNT can be sorted into the columns to the right using @IF.

To set up your own sheet, begin by entering:

```
/GOR
/GF$
```

to calculate across rows and format the sheet to dollars and cents.

On row 1 are labels identifying those lines of Schedule A that require no calculations. On row 2, di-



	D	E	F	G	H	R	Y	Z
1	SCHED A LINE #...	1	2	6A	6B	18	30B	31
2	CODE	1.00	2.00	6.00	6.10	18.00	30.10	31.00
3	--------	--------	--------	--------	--------	--------	--------	--------
4	1.00	976.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	6.00	0.00	0.00	276.78	0.00	0.00	0.00	0.00
7	6.10	0.00	0.00	0.00	193.87	0.00	0.00	0.00
8	26.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	12.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	18.00	0.00	0.00	0.00	0.00	132.98	0.00	0.00
11	17.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	21.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	11.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	13.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15		0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	--------	--------	--------	--------	--------	--------	--------	--------
17		976.00	0.00	276.78	193.87	132.98	0.00	0.00
18	========	========	========	========	========	========	========	========
19								
20								
21								
22	1	2	3	4	5			
23	2300	3400	1700	2300	3400			
24	--------	--------	--------	--------	--------			

FIGURE 6. *This figure shows a portion of the sheet containing some of the columns into which the deductible items are sorted. If you do not have @IF, use* >E4:@INT(D4/E2)∗@INT(E2/D4)∗C4 *and replicate it down the column with the value references as* RNNRR. *As long as none of the codes are zeroes, that expression will work.*

rectly beneath the labels, are the codes used in the sort. Enter those rows exactly as shown in the list below:

```
>E2:1                  >P2:+02+1
>F2:2                  >Q2:17
>G2:6                  >R2:+Q2+1
>H2:+G2+.1             >S2:+R2+1
>I2:+H2+.1             >T2:21
>J2:+I2+.1             >U2:+T2+.1
>K2:11                 >V2:22
>L2:+K2+1              >W2:26
>M2:+L2+1              >X2:30
>N2:13.1               >Y2:+X2+.1
>02:+M2+1              >Z2:31
```

Now enter the labels and amounts shown in Figure 5 under PAID TO, AMOUNT, and CODE in rows 4 . . . 14.

The entry at C8 is negative, indicating that it is income, not a deduction. We've assumed that a casualty loss has been incurred and that $175 of the loss has been paid by insurance. Although we must later change the sign of any reimbursement, it should be entered as a negative here to indicate the true nature of the entry.

The general form of the expression required to perform the sort is:

@IF (COL HEADING = CODE, AMOUNT, 0)

On our sheet that is entered as:

```
>E4:@IF(D4=E2,C4,0)
```

That compares the code in column D with the code in row 2 and, if they are equal, brings the amount in column C into E4. If the two codes are not equal, a zero is entered at E4.

Replicate the expression down the column. Enter:

```
>E4:/R:E5 . . . E15:RNR
```

Now add the column with @SUM, entering:

```
>E17:@SUM(E4 . . . E16)
```

Notice that we have included the line of dashes in the range to be added, so that additional rows can be inserted above row 16 and still be included in the range.

Your sheet should now include a column beginning with 976.00, followed by a series of zeroes and ending with 976.00.

The next step is to replicate that column across the sheet. The term "NRN", containing the value references to replications of the @IF portion of the command will have to be repeated 12 times to fill out the sheet. Enter:

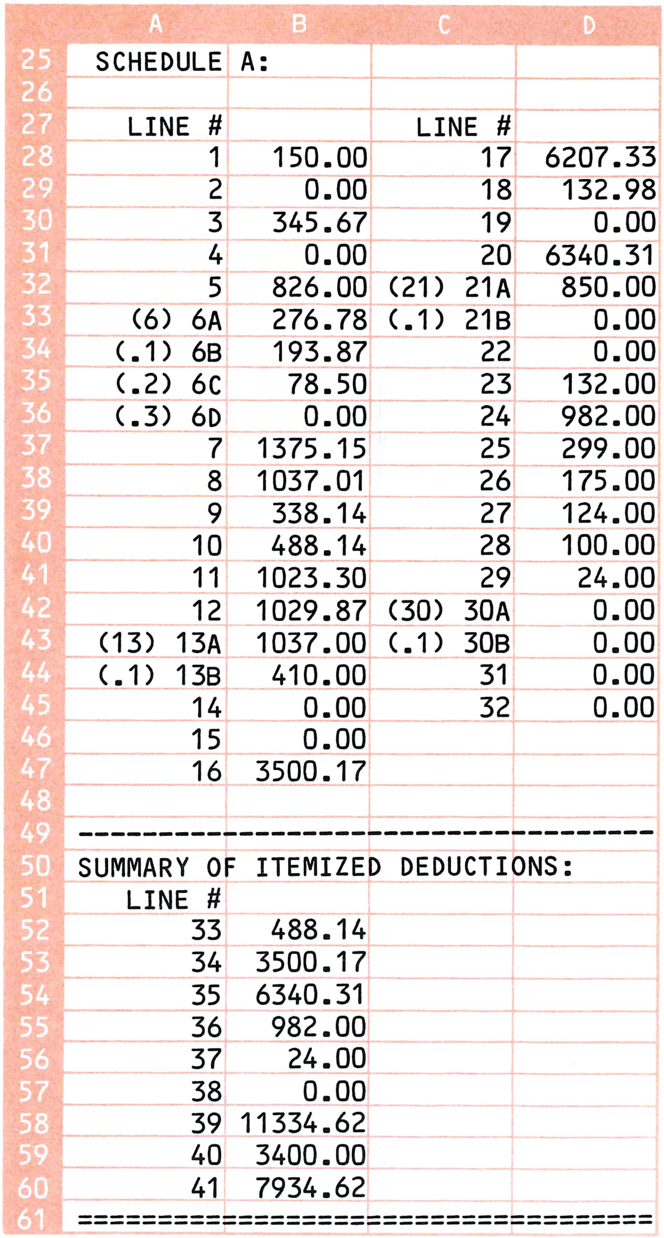
```
>E4:/RE5 . . . E17:F4 . . . Z4:NRNRR
```

Now, if you scroll the sheet horizontally, the middle term of the @IF expressions, referring to the code, changes. Scroll vertically and the middle term remains the same.

Filling in the Data

Once your deductions are sorted and added, there are several items that must be entered on the sheet and that are taken either from Form 1040 itself, or from other records. Those values are shown on our sheet in rows 19 . . . 23. The first is the amount shown on Line 31 of Form 1040. We have entered $34567.00 at B19, next to the label 1040 L31. At B20, B21, and B22 we have entered a casualty loss of $299.00, a charitable contribution carryover of $132.00, and a sales tax of $1037.00 (the latter is from the tax tables referred to on Schedule A).

Sales taxes can be treated two ways: Taken from tables found in the instructions accompanying Form 1040, or on an item by item basis. As we have constructed the sheet, it provides for both approaches, because it includes the entry at B22 and a column coded in row 2 as 13 (at M2). However, although we have provided for both approaches, only one of the figures may be brought down to the part of the sheet shown in Figure 7.



	A	B	C	D
25	SCHEDULE	A:		
26				
27	LINE #		LINE #	
28	1	150.00	17	6207.33
29	2	0.00	18	132.98
30	3	345.67	19	0.00
31	4	0.00	20	6340.31
32	5	826.00	(21) 21A	850.00
33	(6) 6A	276.78	(.1) 21B	0.00
34	(.1) 6B	193.87	22	0.00
35	(.2) 6C	78.50	23	132.00
36	(.3) 6D	0.00	24	982.00
37	7	1375.15	25	299.00
38	8	1037.01	26	175.00
39	9	338.14	27	124.00
40	10	488.14	28	100.00
41	11	1023.30	29	24.00
42	12	1029.87	(30) 30A	0.00
43	(13) 13A	1037.00	(.1) 30B	0.00
44	(.1) 13B	410.00	31	0.00
45	14	0.00	32	0.00
46	15	0.00		
47	16	3500.17		
48				
49	----------	----------	----------	----------
50	SUMMARY OF ITEMIZED DEDUCTIONS:			
51	LINE #			
52	33	488.14		
53	34	3500.17		
54	35	6340.31		
55	36	982.00		
56	37	24.00		
57	38	0.00		
58	39	11334.62		
59	40	3400.00		
60	41	7934.62		
61	==========	==========	==========	==========

FIGURE 7. *After completing this portion of the sheet you are ready to fill out Schedule A manually. If you do not have @CHOOSE use this expression:* >B59:@LOOKUP(B23,D22 . . . G22).

VISICALC POINTER . . .

Is there a way to perform a quick recalculation on a large, complex sheet?

You've probably noticed that when you use /E, the display is recalculated immediately when you type ®. When you have developed a sheet that takes a long time to recalculate, and you want to see how a change in one or two variables will affect values that depend directly on those variables, you can use /E. This technique assumes, of course, that you have entered /GRM.

After entering the new variable, go to the next cell that uses that variable and enter /E ®. That cell will then be recalculated, showing the effect of the change without the necessity of recalculating the entire sheet.

As an example, in the article in this issue that shows how to determine the deposit needed to produce some amount of income from an IRA, if you wish to change the number of years the income will be payable for, you do not have to recalculate the entire sheet. Simply enter the new number of years, then go to C18 and C19, in turn entering /E ®, and the new deposit amount will be displayed at once.

On row 23, labelled STATUS, are the so-called "zero bracket" amounts found on line 40 of Schedule A.

The sums calculated on row 17 must be brought down to the section of the sheet that begins at A25 with the label SCHEDULE A:. On this part of the sheet we have reproduced, in order, each line of Schedule A with labels identifying the lines and the codes that head the columns into which deductions have been sorted. Enter the labels in A27 . . . A60 and C27 . . . C45, as shown in Figure 7.

Now split the screen and set a horizontal title line at A2. Enter:

```
>A1:>A6:/WH>A2:/TH>A18
```

The upper window now displays rows 1, 2, 16, 17, and 18. If you scroll the upper window horizontally, you can read the sums at the foot of each column and the two lines at the top of the sheet that identify the codes and the lines on Schedule A to which the codes correspond.

To enter the amounts in the various columns in the appropriate locations below, you must first change windows. Enter:

```
>A18:;>B29
```

To bring each value down to the summary section calls for the use of the same command sequence, which in general terms is

>Coordinate 1: + ; ⇒ Coordinate 2 ®

(The symbol ⇒ means "scroll to.") Notice that you cannot use the GO TO COORDINATE (>) command after having entered the + sign, since the VisiCalc program will read the symbol as a comparison operator. That is, once you have crossed the window boundary by using the semicolon, you will have to scroll across row 17 to locate the right column total.

The value needed at B29 is expense for medicine and drugs, which is in the column coded 2, and added at F17. Enter:

```
>B29:+F17
```

which can be entered as shown or fetched from row 17 with the general command sequence shown above. The following list shows the locations of each of the values from the sort.

```
>B29:+F17
>B33:+G17
>B34:+H17
>B35:+I17
>B36:+J17
>B41:+K17
>B42:+L17
>B44:+N17
>B45:+O17
>B46:+P17
>D28:+Q17
>D29:+R17
>D30:+S17
>D32:+T17
>D33:+U17
>D34:+V17
>D38:-W17
>D42:+X17
>D43:+Y17
>D44:+Z17
```

Notice that the entry at D38 changes the sign of the sum at W17. Changing the sign is necessary, because we want to display all values exactly as they should be entered on each line of Schedule A.

After completing those entries, return to a single window with /W1. The title boundary that you created with /TH will no longer exist, so if you wish to retain it, you will have to return to A2 and re-enter the command.

There are still three uncalculated itemized deductions that must be entered on the sheet. Since the general sales tax may be taken from the tax tables or from documented actual taxes paid, the entry at B43 chooses the larger. Enter:

```
>B43:@MAX(B22,M17)
```

The casualty loss and charitable contribution carryover are included in the form with the entries:

```
>D35:+B21
>D37:+B20
```

Calculated Values on Schedule A

Several of the lines on Schedule A require calculations, of course, and rather than duplicate the instructions for performing them, we suggest that you refer directly to the form for the details. In the expressions that follow, we have identified both the general categories into which the necessary expressions are grouped, the lines on Schedule A to which the expressions refer, and the cells on the sheet into which they should be entered.

Lines 1-10 of Schedule A cover medical and dental expenses and require several calculations.

SCHEDULE A:	EXPRESSION
LINE 1	`>B28:@MIN(E17*.5,150)`
LINE 3	`>B30:+B19*.01`
LINE 4	`>B31:@MAX(B28-B30,0)`
LINE 5	`>B32:+E17-B28`
LINE 7	`>B37:@SUM(B31...B36)`
LINE 8	`>B38:+B19*.03`
LINE 9	`>B39:@MAX(-B38+B37,0)`
LINE 10	`>B40:+B39+B28`

Taxes, other than Federal, are summarized on Line 16:

SCHEDULE A:	EXPRESSION
LINE 16	`>B47:@SUM(B41...B46)`

Interest expense is totalled on Line 20:

SCHEDULE A:	EXPRESSION
LINE 20	`>D31:@SUM(D28...D30)`

And contributions on Line 24:

SCHEDULE A:	EXPRESSION
LINE 24	`>D36:@SUM(D32...D35)`

Casualty losses, like medical expenses, require several calculations. Because we have changed the sign of the insurance reimbursement, we use the @MAX function:

SCHEDULE A:	EXPRESSION
LINE 27	`>D39:@MAX(D37-D38,0)`
LINE 28	`>D40:@MIN(100,D39)`
LINE 29	`>D41:+D39-D40`

Finally, miscellaneous deductions are totalled on Line 32:

SCHEDULE A:	EXPRESSION
LINE 32	`>D45:@SUM(D42...D44)`

Summarizing the Deductions

At the bottom of Schedule A is the Summary of Itemized Deductions, the lines and expressions for which are:

SCHEDULE A:	EXPRESSION
LINE 33	`>B52:+B40`
LINE 34	`>B53:+B47`
LINE 35	`>B54:+D31`
LINE 36	`>B55:+D36`
LINE 37	`>B56:+D41`
LINE 38	`>B57:+D45`
LINE 39	`>B58:@SUM(B52...B57)`
LINE 40	`>B59:@CHOOSE(B23,D23...G23)`
LINE 41	`>B60:+B58-B59`

Now it should be possible for you to return to the top of your sheet and begin entering your actual itemized deductions. Should you need more lines for data entry than we have provided, they may be inserted simply enough above row 16 and replicated across the sheet.

We should also point out that if you use the VisiCalc program as a checkbook register, then depending on how you have laid out the sheets for that purpose, you may only have to create a DIF file that can be inserted in the upper left of the sheet you have created to accompany this article. Indeed, as we mentioned in "About This Issue," the general approach used to identify the categories into which your deductions are sorted can be applied to any problem in which it is desirable to categorize entries. You may not itemize deductions, but if, for example, you use the VisiCalc program as a checkbook register or for a double entry general ledger, you can automatically sort entries by category, simply by devising a coding system of your own.

CALCULATING INTERNAL RATES OF RETURN

One way of measuring an investment's performance is to determine its internal rate of return (IRR). One of the problems associated with IRR calculations, however, is that finding the solution often requires several recalculations, or iterations. Making matters even more complex, certain kinds of problems may have more than one solution.

In this article we will show you two different ways to solve IRR problems, one relatively simple and the other more complex. For those who are already familiar with the basic idea behind IRR calculations, we suggest skipping to the section headed "Constructing an IRR Table."

For a more detailed explanation of IRR than we provide, consult *Managerial Finance* by J. Fred Weston and Eugene F. Brigham (Hinsdale, IL: The Dryden Press, 1981) or *Financial Analysis* by Jerry A. Viscione (Boston, MA: Houghton Mifflin, 1977).

IRR Basics

Internal rate of return calculations are used widely to analyze real estate investments, particularly tax shelters. They may also be used when deciding on equipment purchases, since they can often answer the question: If we buy this piece of machinery, will its cost be offset by reduced manufacturing costs or increased productivity? And since the definitions of IRR and "yield to maturity" of a bond are identical, the techniques we will describe can be used for bond analysis, too.

The calculations deal with three factors; an investment amount, an income amount, and an interest rate. The investment is conventionally stated as a negative value, since it is money going out. Income, on the other hand, is stated as a series of values, each received at the same interval, and which may be positive or negative. (Some vehicles may require the investor to make additional payments after the first. Those payments may be greater than the income for that year, and so they are stated as negatives. Or, in some cases, a negative income may occur when excess depreciation is recaptured.) Since the income, whether positive or negative, occurs in the future, it must be discounted by some rate to reflect lost opportunities for putting the money to work in other investments, the cost of money, and inflation.

The IRR of an investment is defined as that interest rate which the net present value of the income, or savings, equals the amount invested. If the two are equal, then the following general formula applies:

Net Present Value of Income – Investment = 0

Note that because the investment is typically stated as a negative value, some of the VisiCalc® expressions we shall use contain plus (+) signs in place of the minus (–) sign used in the general expression.

Calculating net present value requires that you assume some interest rate. As the general formula suggests, if the interest rate you use produces a net present value that is not equal to the investment, there will be a remainder, stated either as a negative or positive difference in dollars. If the investment exceeds the net present value, the difference will be negative, indicating that the interest rate chosen was too low. On the other hand, if income exceeds investment, the difference is positive, and the rate chosen too high.

Clearly, then, making the two values equal requires repeatedly guessing at the rate. Many calculators require you to reenter each step in a long sequence of calculations in order to approach the interest rate. As you will see, the methods that we show also require some iteration. However, we have designed them to minimize the number of keystrokes and iterations required.

Constructing an IRR Table

The first, and simplest, of the ways to calculate IRR is to create a table that tests a large number of rates. Figure 8 shows a sheet on which such a table has been entered.

Before constructing the table, though, it is useful to break down the calculation of a simple IRR problem. That is done on the same sheet on which we constructed the table.

To reproduce the sheet begin by entering the labels shown. Enter the values shown at B3, next to the label INVEST, and at B6 and B7. In cells A6 . . . A10 enter values numbering the years.

We have assumed that after investing $5000, the investor's first year return is the only positive one, the second being negative. That is, in return for $15000, the investor gets back $14773. At first glance that seems absurd, but when the present value of $10000 payable by the investor is calculated at a discounted rate of, say, 15%, it evaluates to $7561.44. At the same rate, the present value of $14773 paid to the investor after one year is $12846.09. Those values are calculated in column C using an expression for calculating the present value of a single sum, and replicating it into a few cells. Enter:

```
>C4:.15
```

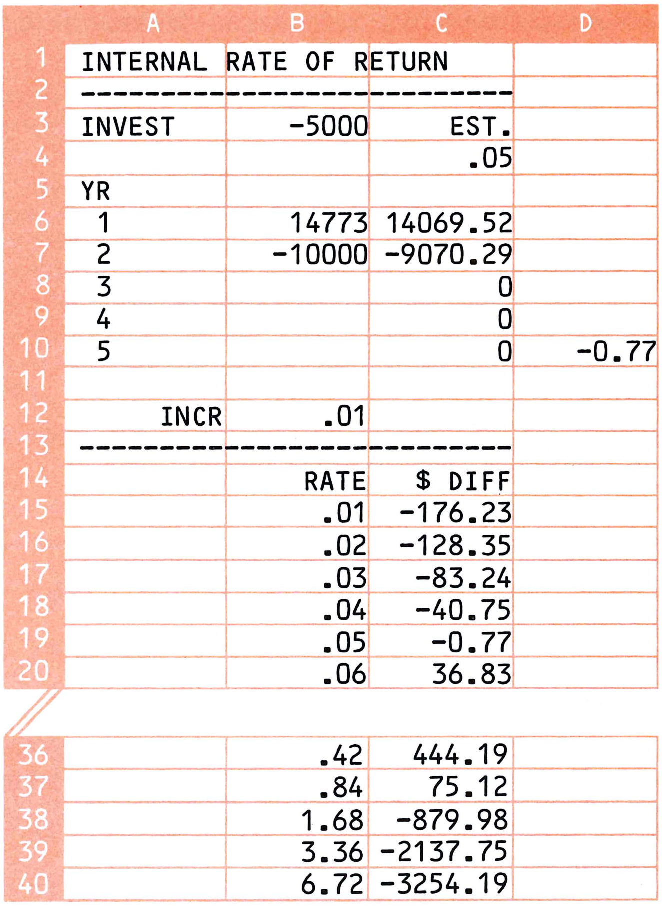
That is a first guess.

Now enter the expression used to calculate the present value of a single sum:

```
>C6:+B6*(1+C4^-A6)
```

That shows that the present value of the $14773 due one year hence and discounted at 15% is $12846.09. Now replicate the expression at C6 into C7 . . . C10. Enter:

```
>C6:/R:C7 . . . C10:RNR
```



	A	B	C	D
1	INTERNAL RATE OF RETURN			
2	---------------------------			
3	INVEST	-5000	EST.	
4			.05	
5	YR			
6	1	14773	14069.52	
7	2	-10000	-9070.29	
8	3		0	
9	4		0	
10	5		0	-0.77
11				
12	INCR	.01		
13	---------------------------			
14		RATE	$ DIFF	
15		.01	-176.23	
16		.02	-128.35	
17		.03	-83.24	
18		.04	-40.75	
19		.05	-0.77	
20		.06	36.83	
36		.42	444.19	
37		.84	75.12	
38		1.68	-879.98	
39		3.36	-2137.75	
40		6.72	-3254.19	

FIGURE 8. *For relatively infrequent IRR calculations a table like the one shown here is usually sufficient. Each of the values in column C is the difference between the amount invested and the net present value of the income.*

Now, at D10, enter:

```
>D10:/F$@SUM(C6 . . . C10)+B3
```

The value at D10, 284.65, is the difference between the present values of the income and the investment. Since it is positive, the rate .15 is too high. Go back to C4 and change the guess to .05 and the value at D10 will evaluate to –0.77, indicating that 5% is close, but too low. The IRR of this investment, to be exact, is 5.02%.

Constantly changing the guesses at C4 is time consuming, and the series of expressions used to calculate the present values year by year, and then add them, can all be performed with @NPV function of the VisiCalc program.

Using @NPV we are able to construct a table that allows us to repeat the calculations frequently enough to spot those points at which a change of sign occurs, and then to zero in more efficiently on the rates closest to the solutions.

To begin, enter:

```
>B12:.01
```

We will use that entry as an incremental value for recalculation.

At B15 enter:

```
>B15:.01
```

That entry gives us the first of the rates that will be tested.

The second and subsequent rates are produced by the entry:

```
>B16:+B12+B15
```

That is replicated down the column with the entry:

```
>B16:/R:B17 . . . B35:NR
```

Thus, each successive rate is .01 greater than the one before. In order to test a few values that are substantially higher than those entered above, we can double the value at B35 and then perform a few more doublings. Enter:

```
>B36:+B35*2®/R:B37 . . . B40:R
```

The column on your sheet should now begin with .01, which is 1%, and end with 6.72, or 672%.

Now we want to use those values in the calculation of the IRR of the investment and income shown above. Enter:

```
>C15:@NPV(B15,B6 . . . B10)+B3
```

By replicating that expression down the sheet, we can test all the values in column B. Enter:

```
>C15:/R:C16 . . . C40:RNNN
```

The values that will be displayed in column C show that at 5% the difference between the investment and the net present value of the income is −0.77, but that at 6% it is 36.83. In short, the IRR of the investment is between 5% and 6%, and, as we know, much closer to 5% than 6%. However, if you scroll down the column, you will see that the dollar difference rises, then falls. At 84% it is 75.12, but at 168% it is −879.98, which says that there is a second solution to this problem.

To approach the second solution more closely, return to B15 and enter:

```
>B15:.84
```

The newly calculated table shows that the second solution lies somewhere between 90% and 91%. In order to find the exact rate, we can change the incremental value at B12 to .001, and the value at B15 to .901. After making those entries, you will see that the second solution is between 90.4% and 90.5%.

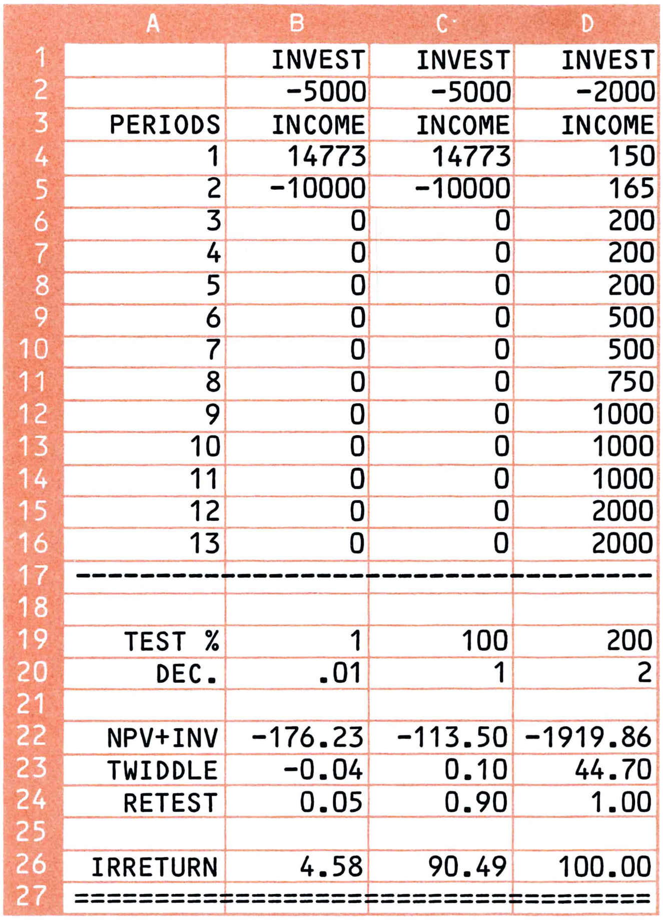
In most cases there is only one solution to any IRR problem, and it is not necessary to look for more than one rate. One advantage of using a table of the sort we have just developed is that it allows you to identify a trend up or down, and so determine whether a given investment may have more than one IRR. Another is that it allows you to test a large number of values simultaneously.

If using an IRR table suits your purposes, so much the better. However, if you must calculate IRR frequently, there is a quicker way to find it. The technique that follows requires fewer keystrokes, but is mathematically sophisticated. If you do not require IRR calculations frequently, we suggest that you forego the remainder of this article.

IRR Calculations with Newton's Method

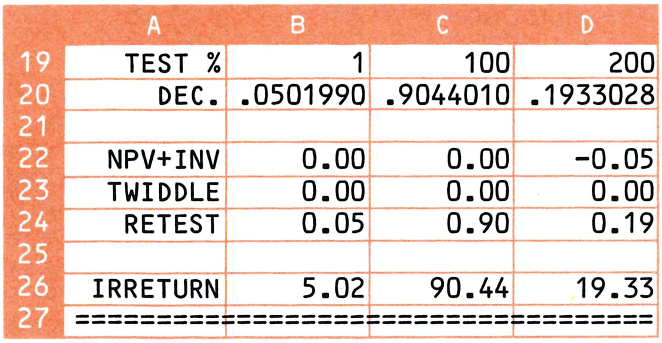
Taking the tabular approach to IRR is a form of trial and error. The approach that follows is essentially trial and error, too. But rather than repeating the entire calculation over and over again, this approach bases the new guess on the amount of error in the preceding guess. In general, iterative algorithms are valuable mathematical tools, but they suffer from one drawback. Given certain problems or conditions, they may take you further from a solution rather than closer to it. That is, at times instead of proceeding directly toward a solution the results begin "bouncing" widely between increasingly incorrect values. Newton's method is subject to the same drawback, but usually far less often than other methods. Moreover, to protect against such bouncing, we have added an expression that damps them.

Starting with a clear sheet, enter the labels shown in Figure 9. Enter the investment and income values shown. We have used the same investment example for this application as in the one above, since we already



	A	B	C	D
1		INVEST	INVEST	INVEST
2		-5000	-5000	-2000
3	PERIODS	INCOME	INCOME	INCOME
4	1	14773	14773	150
5	2	-10000	-10000	165
6	3	0	0	200
7	4	0	0	200
8	5	0	0	200
9	6	0	0	500
10	7	0	0	500
11	8	0	0	750
12	9	0	0	1000
13	10	0	0	1000
14	11	0	0	1000
15	12	0	0	2000
16	13	0	0	2000
17	----------------	----------------	----------------	----------------
18				
19	TEST %	1	100	200
20	DEC.	.01	1	2
21				
22	NPV+INV	-176.23	-113.50	-1919.86
23	TWIDDLE	-0.04	0.10	44.70
24	RETEST	0.05	0.90	1.00
25				
26	IRRETURN	4.58	90.49	100.00
27	==========	==========	==========	==========

FIGURE 9. *If you do not have @IF use @ABS(B20 – B23) at B24 and replicate it relatively into C24 . . . D24. In that event, if the value returned on row 23 is greater than 1, do not return the value on row 24 to row 20 for recalculation or your results will begin bouncing. Rather, halve the initial guess, and keep halving, until the value on row 23 falls to less than 1, then carry row 24 to row 20.*



	A	B	C	D
19	TEST %	1	100	200
20	DEC.	.0501990	.9044010	.1933028
21				
22	NPV+INV	0.00	0.00	-0.05
23	TWIDDLE	0.00	0.00	0.00
24	RETEST	0.05	0.90	0.19
25				
26	IRRETURN	5.02	90.44	19.33
27	=========	=========	=========	=========

FIGURE 10. *The sheet in Figure 9 showed that the values in B24 and C24 were within 1% of the solutions without any recalculations. After four iterations using !, the value at D24 is also within 1%. The IRR of the problems shown are for all practical purposes completely calculated after six iterations. The expressions in Row 24 make rate bounces highly unlikely.*

know roughly which rates to expect. We have also entered an example of a more typical problem.

In row 19, in the field labelled TEST %, we have entered our initial guesses. Directly beneath those guesses, in the DEC. field, are the decimal equivalents of the TEST % entries. Enter:

```
>B20:+B19/100®/R:C20 . . . D20:R
```

At B22 is an entry that gives the dollar difference between the investment and the net present value of the income. The form of the expression in that cell is identical to the one used in the table above. Enter:

```
>B22:/F$@NPV(B20,B4 . . . B17)+B2
>B22:/R:C22 . . . D22:RRRR
```

Explaining the following two expressions in rigorous mathematical terms would require a great deal of space, and take us too far afield. In general terms, what they do is take the dollar difference calculated in row 22 and use it as the basis for a new guess. The rate used for the new guess, though, is slightly higher than the one used at B22. What we have done is to multiply the first guess, entered at B20, by 1.01. (One of the points to keep in mind about that, of course, is that when you use @NPV in other applications, the rate used can be a value reference, a value, or, as here, a calculation.) Enter:

```
>B23:/F$+B22/(@NPV(1.01*B20,B4 . . . B17)
  -@NPV(B20,B4 . . . B17)/(.01*B20))
```

At B24, the new guess calculated at B23 is compared to the old one, and if it appears that it will bounce too much, it is damped.

```
>B24:/F$+B20-@IF(@ABS(B23)>1,
  @ABS(B20)/2,B23)
```

That expression also allows us to enter a relatively high initial guess, as seen in Figure 9.

Now replicate those expressions into columns C and D, making all value references relative. Enter:

```
>B23:/R:C23 . . . D23:RRRRRRRR
>B24:/R:C24 . . . D24:RRRR
```

At B26, the value returned at B24 is stated as a percent. Enter:

```
>B26:/F$+B24*100®/R:C26 . . . D26:R
```

As you can see from Figure 9, the field NPV + INV, shows that investment and income are not equal. To test the new guesses, return to B20 and enter:

```
>B20:+B24®/R:C20 . . . D20:R
```

If you are in the automatic recalculation mode, the completion of that entry will return new values in rows 23 and 24. If you are in the manual recalculation mode, press !. In either case, the difference between the net present value of the income and the investment should have fallen substantially. Given the initial guesses shown in Figure 9, it took only six recalculations with ! (and something like 15 seconds) to produce the IRRs shown in Figure 10.

We cannot say that this approach is foolproof. We tried it with some truly bizarre examples and with some with known solutions, and it has worked. It is probable that there are examples that will cause this approach to fail (that is, to bounce).

Finally, if you suspect that a problem has more than one solution, we suggest that you enter a very large initial guess as well as a very small one, as we have shown. The reason for that is the expression that damps the variation is so constructed that, given a value well below the higher of the two solutions, it tends to home in on the lower rate.

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